2002 Agency Report to the Canada-U.S. Groundfish Committee's Technical Subcommittee:
Auke Bay Laboratory Contribution

April 2002

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VII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT

A. Agency Overview: NMFS - AFSC - Auke Bay Laboratory

The Auke Bay Laboratory (ABL), located in Juneau, Alaska, is a division of the NMFS Alaska Fisheries Science Center (AFSC). In recent years, ABL's Groundfish Assessment Program has been primarily involved with research and assessment of sablefish and rockfish in Alaska and with the study of fishing effects on the benthic habitat. In 2001, the groundfish program began additional new projects to study the interaction between Steller sea lions and prey/predators in Alaska. Presently, the Groundfish Program is staffed by 16 scientists, including 14 permanent employees, 1 term employee, and 1 temporary. One personnel change that occurred in the Groundfish Program during 2001 was the hiring of Dave Csepp as a term employee to work on Steller sea lion prey studies.

In 2001 field research, ABL's Groundfish Program, in cooperation with the AFSC's RACE Division, conducted the annual NMFS sablefish longline survey in Alaska. Other field work by ABL included 1) a study near Kodiak Island on the effects of trawling on soft-bottom habitat colonized by sea whips; 2) a multibeam echosounder survey of a major fishing ground in the Gulf of Alaska to produce detailed bathymetric and habitat maps for this area; 3) a series of cruises in southeast Alaska to test the hypothesis that juvenile sea lion prey diversity and seasonality are related to Steller sea lion population trends; 4) a longline study in the central Gulf of Alaska to test the hypothesis that sleeper sharks prey on Steller sea lions; 5) ongoing scuba diving studies of growth rates of shallow water coral and sponge species to help determine effects of fishing on these taxa in Alaska; 6) continued juvenile sablefish studies, including tagging of juveniles and a laboratory young-of-the-year sablefish growth study; 7) an ongoing genetics and plankton study to identify rockfish larvae to species; 8) electronic archival tagging of sablefish during the longline survey; and 9) a continuing habitat study of rockfish in nearshore areas of southeastern Alaska.

Ongoing analytic activities involved management of ABL's sablefish tag database and preparation of three annual status of stocks documents for Alaska groundfish: sablefish, slope rockfish, and pelagic shelf rockfish. Other analytic activities during the past year were: 1) a study of the use of echosounder signals to stratify trawl surveys for Pacific ocean perch and thereby improve survey precision; 2) an analysis of the variability of trawl survey catches of Pacific ocean perch, shortraker rockfish, and rougheye rockfish for use in future survey designs; 3) establishment of a sablefish logbook database and computation of longline fishery catch rates; and 4) a study based on past trawl survey

data of the distribution and abundance of various "living substrates" in Alaska and of associations of commercial fish and crab species with these substrates; and. In addition, groundfish program staff spent considerable time preparing a revised Programmatic Supplemental Environmental Impact Statement (SEIS) for the Bering Sea/Aleutian Islands and Gulf of Alaska Groundfish Fishery Management Plans and a new SEIS for essential fish habitat in Alaska.

For more information on overall Auke Bay Laboratory programs, contact Laboratory Director Dr. Michael Dahlberg at (907) 789-6001.

C. By Species, By Agency

2. Shelf Rockfish

a. Research

Distribution and Habitat of Rockfish (*Sebastes* spp.) in Nearshore Waters of Southeast Alaska

Scientists in the ABL Habitat Program continued to assess the distribution, habitat, and behavior of rockfish in nearshore waters of southeastern (SE) Alaska. Two sampling cruises were conducting in 2001 using the NOAA RV *John N. Cobb*. Methods included use of a beach seine to capture fish in shallow (<10 m deep), vegetated habitats (e.g., eelgrass meadows, understory kelps) and use of a remotely operated vehicle (ROV) to record *in situ* observations of rockfish in deeper water (10-90 m) habitats such as vertical bedrock walls and complex bottoms of boulders or broken rock. To date, 127 seine hauls and 244 ROV dives have been completed at 44 sites throughout SE Alaska. Of the over 30 species of rockfish known to occur in Alaska, 16 species were captured or observed in nearshore waters of SE Alaska. Studies in 2002 will focus on linking rockfish assemblages to specific habitat types in nearshore waters of SE Alaska. Different habitats (e.g., pinnacles, gullies) will be identified from detailed bathymetric maps and ROV surveys will be conducted in these areas. The ROV will be equipped with a GPS tracking system that will allow us to map the distribution of fish by habitat type.

For more information, contact Scott Johnson at 907-789-6063 or John Thedinga 907-789-6025.

b. Stock Assessment

GULF OF ALASKA

Pelagic Shelf Rockfish

The pelagic shelf rockfish assemblage is comprised of three species (dusky, yellowtail, and widow rockfish) that inhabit waters of the continental shelf of the Gulf of Alaska and that are thought to exhibit midwater, schooling behavior. At certain times, however, some of these fish are caught in bottom trawls. Dusky rockfish is by far the most abundant species in the group, and has been the target of a bottom trawl fishery since the late 1980's. Two varieties of dusky rockfish are seen: an inshore, dark-colored form, and a light-colored variety found offshore. The trawl fishery takes the light variety. Recent taxonomic work indicates these two forms are separate species, and a publication presenting this information is currently in preparation by Jay Orr of the AFSC RACE Division.

Similar to previous years, ABC for the assemblage in 2002 is calculated using biomass estimates based on trawl survey data. Gulfwide exploitable biomass, 62,489 mt, is based on the average of the biomasses estimated for the assemblage in the three most recent trawl surveys of this region (those in 1996, 1999, and 2001). This biomass is comprised of 56,336 mt for dusky rockfish and 6,153 mt for yellowtail and widow rockfish. Applying an F=M strategy to the biomass for dusky rockfish, in which the annual exploitation rate is set equal to the estimated rate of natural mortality for dusky rockfish (0.09), yields a Gulfwide ABC of 5,070 mt. Applying a more conservative F=0.75 x M strategy to the biomass for yellowtail and widow rockfish (in which the M for dusky rockfish is also applied to the former two species), yields an ABC of 415 mt. Total recommended Gulfwide ABC for the assemblage in 2002 is the addition of these two ABC values: 5,485 mt.

For the first time, data were collected in 2001 for development of an age-structured model for dusky rockfish using the AD Model Builder template. Exploratory runs for the model will be presented to the Gulf of Alaska Groundfish Plan Team in 2002.

For more information, contact David Clausen at (907) 789-6049 or Jon Heifetz at (907) 789-6054.

3. Slope Rockfish

a. Research

GULF OF ALASKA

Application of Echosounder Signal to Improve Trawl Survey Precision for Pacific Ocean Perch

ABL staff have been examining ways to improve trawl survey design for Pacific ocean perch, including methods for efficiently increasing sample size and precision. One way to increase sample size with minimal effort is to collect hydroacoustic signals, both during trawl hauls and between hauls. Further evaluation of this technique to improve rockfish survey precision continued during 2001. Echosounder signals were recorded with a Simrad ES60 echosounder during the 2001 Gulf of Alaska trawl survey. Dana Hanselman, a PhD graduate student at the University of Alaska Fairbanks, Juneau Center for Fisheries and Ocean Sciences, is currently processing these data and has done some preliminary evaluation. Plans are underway by AFSC rockfish scientists and RACE survey scientists

to collect further data in 2002 during the Aleutian Islands trawl survey and the Bering Sea slope trawl survey. Also, ABL scientists are planning an experimental application this summer of double sampling with echosounder signal at a study site off Cape Ommaney, southeast Alaska for surveying Pacific ocean perch.

For more information, contact Jeff Fujioka at (907) 789-6026.

Variability in Trawl Survey Catches of Pacific Ocean Perch, Shortraker Rockfish, and Rougheye Rockfish in the Gulf of Alaska

All the abundant species of slope rockfish in Alaska are usually assumed to be extremely variable or clustered in their distribution. Little analysis, however, has been done on this subject, especially regarding comparisons of variability among the different species. In this study, ABL scientists first examined data for Pacific ocean perch, shortraker rockfish, and rougheye rockfish from three experimental bottom trawl surveys in the Gulf of Alaska in 1993, 1998 and 1999 to compare the variability of catches for each species. Although these surveys were relatively small in scope, they all used the same survey vessel and the same experienced rockfish commercial captain, together with a net specifically designed for catching rockfish. Thus, they likely provide some of the best survey data available for these three species in Alaska. When catches of each species were analyzed within their optimum habitat, the coefficient of variation for Pacific ocean perch was approximately 2.5 to 3 times greater than that of shortraker and rougheye rockfish, indicating that Pacific ocean perch are much more clustered in their distribution. Shortraker and rougheye rockfish were similar to each other in their variability.

To provide additional comparisons of variability over a broader geographic area, catches of the three species were also examined from 7 large-scale trawl surveys conducted in the Gulf of Alaska from 1984 to 2001. Again, the analysis only included hauls that were made within the optimum habitat for each species. Results were very similar to the previous results from the experimental surveys: variability of Pacific ocean perch catches was about 2-3 greater than that for either shortraker or rougheye rockfish. Overall results of this study indicate that a stratified random trawl survey directed at shortraker and rougheye rockfish would be logistically feasible, because the low variability of these two species would require relatively few hauls to be made. However, a similar random survey aimed at a highly variable species such as Pacific ocean perch is probably not feasible because it would require too many stations to be cost effective. New and innovative methodologies for surveying Pacific ocean perch, such as the use of echosounders in combination with trawling (described in the section immediately above), will be necessary to improve assessment of this species.

For more information, contact David Clausen at (907) 789-6049.

Species Identification of Rockfish Larvae and Other Larval Rockfish Studies

Rockfish (*Sebastes* spp.) larvae and early post larvae present vexing problems in marine ecology. As a group they are most abundant in the spring and early summer zooplankton where they may have important trophic roles. Although easily identified to genus, specific identification of *Sebastes* larvae using morphology and pigmentation patterns is very difficult. ABL scientists in cooperation with Dr. Anthony Gharrett of the University of Alaska Fairbanks, Juneau Center for Fisheries and Ocean Sciences, have attempted to resolve some of the difficulty using genetic techniques. Recombinant mitochondrial DNA (mtDNA) analysis has been used to identify individual *Sebastes* larvae that were photographed before preservation. Fourteen of 33 species known to occur in southeast Alaska have been identified from plankton samples in the area.

The genetic analysis and photographic comparisons indicate that several species have identical or similar pigmentation patterns during the preflexon stage. Additionally, several different pigmentation patterns have been attributed to the same species using mtDNA analysis. Although pigmentation patterns and morphology do not appear to be reliable characters to identify species of *Sebastes* larvae from field collections, we are analyzing our data to determine if pigment patterns can be used to distinguish subgenera or other species groupings.

For more information, contact Bruce Wing at (907) 789-6043.

b. Stock Assessment

GULF OF ALASKA

Slope rockfish are defined as those species of *Sebastes* that, as adults, inhabit waters of the continental slope and outer continental shelf, generally in depths greater than 150-200 m. Twenty-one species of rockfish are classified into the slope assemblage, the most abundant of which are Pacific ocean perch, and northern, rougheye, redstripe, sharpchin, shortraker, silvergrey, and harlequin rockfish. Until 1993, the stock abundance of slope rockfish, especially Pacific ocean perch, was considered to be quite depressed compared to its former abundance in the early 1960's. The 1993 trawl survey of the Gulf of Alaska showed a substantial increase in biomass of Pacific ocean perch. This increase has continued in subsequent years based on trawl surveys in 1996, 1999, and 2001, and this suggests that current abundance of Pacific ocean perch is much improved in comparison with its formerly depressed condition. Age-structured models are applied to Pacific ocean perch and northern rockfish. Based on these models, the best estimate of exploitable biomass for Pacific ocean perch in the Gulf of Alaska is now 293,240 mt, and the exploitable biomass for northern rockfish is 94,350 mt. Exploitable biomass for all other species in the assemblage is presently estimated from the average values in the 1996, 1999 and 2001 trawl surveys, and totals 66,830 mt for shortraker/rougheye rockfish, and 107,960 mt for other species of slope rockfish. Development of an age-structured model

for rougheye rockfish was initiated this year using the AD Model Builder template, but this model is still in a very preliminary stage.

To prevent possible over-exploitation of the more desirable species, the slope rockfish assemblage is divided into four subgroups: Pacific ocean perch, shortraker/rougheye rockfish, northern rockfish, and other slope rockfish. Separate ABC's are assigned to each subgroup. Pacific ocean perch and northern rockfish are presently managed using an $F_{40\%}$ strategy adjusted for relative spawning biomass. The other subgroups are managed under an F=M strategy, in which the annual exploitation rate is set equal to or less than the rate of natural mortality. The 2002 ABC's are as follows: Pacific ocean perch, 13,190 mt; shortraker/rougheye rockfish, 1,610 mt; northern rockfish, 4,980 mt, and other slope rockfish, 5,040 mt.

For more information, contact Jonathan Heifetz at (907) 789-6054, James Ianelli at (206) 526-6510, or David Clausen at (907) 789-6049.

5. Sablefish

a. Research

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

Sablefish Longline Survey

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987-2001. The survey is a joint effort involving two divisions of the AFSC: ABL and RACE. It replicates as closely as practical the Japan-U.S. cooperative longline survey conducted from 1978-94 and also samples gullies not sampled during the cooperative longline survey. In 2001, the twenty-third annual longline survey of the upper continental slope of the Gulf of Alaska was conducted, along with a similar survey of the eastern Bering Sea slope. One hundred-fifty-three longline hauls (sets) were completed between 2 June 2001 and 3 September 2001 by the chartered fishing vessel *Ocean Prowler*. Sixteen kilometers of groundline were set each day, containing 7200 hooks baited with squid.

Sablefish (*Anoplopoma fimbria*) was the most frequently caught species, followed by giant grenadiers (*Albatrossia pectoralis*), Pacific cod (*Gadus macrocephalus*), and arrowtooth flounder (*Atheresthes stomias*). A total of 94,033 sablefish were caught during the survey. A total of 4,323 sablefish, 626 shortspine thornyhead (*Sebastolobus alascanus*), and 128 Greenland turbot (*Reinhardtius hippoglossoides*) were tagged and released during the survey. Length-weight data and otoliths were collected from approximately 2,500 sablefish. Sperm (*Physeter macrocephalus*) and killer (*Orcinus orca*) whales took fish from the longline at several stations, as in previous years, and may have affected catch rates at these stations.

For more information, contact Chris Lunsford (907) 789-6008

Sablefish Logbook Database and Fishery Catch Rates

A sablefish logbook program was initiated by ABL in 1999 to collect detailed fishery information to better understand fishery characteristics and improve the sablefish assessment in Alaska. Vessel logbooks are required from sablefish longline vessels over 60 feet in length. Voluntary logbooks are also submitted by vessels less than 60 feet and are included in the data set when available. The individual logbook sheets are designed to collect catch and effort information for all sablefish sets made by a vessel. With this information, catch rates for the fishery can be computed and compared to catch rates from the NMFS longline survey. A logbook database is now operational and currently contains data from 1999 and 2000. The 2001 data should be available by June 2002.

Preliminary work on fishery catch rates was conducted in 1999 using data collected by the domestic observer program. The analysis of catch rate trends is an important step in incorporating both survey and fishery data into the management process. More extensive analysis of fishery data is warranted because some fishermen are concerned that their catch rates have remained strong in some areas despite declines in longline survey catch rates. Using data that is now available from the sablefish logbook program and the domestic observer program, fishery catch rates are computed annually and included in the sablefish assessment model.

For more information, contact Chris Lunsford (907) 789-6008 or Michael Sigler at (907) 789- 6037.

ABL Sablefish Tag Recovery Program

Processing tag recoveries and administration of the reward program continued during 2001. About 600 tags have been received so far this year, down slightly from the last three years. Over 17% of the fish recovered in 2001 had been at liberty longer than 15 years. The three fish at liberty the longest (28+ years) were all released in upper Chatham Strait in 1973. Two were recovered in Chatham Strait and one off Queen Charlotte Sound in Canada.

Tagging continued on the 2001 sablefish longline survey, with 4,323 sablefish tagged and released. Tag releases in the database, including adults and juveniles, now total 308,970. There are 24,004 recoveries to date.

An additional 1,002 sablefish were tagged and released on three seamounts in July when the longline survey vessel transited from the Western to Eastern Gulf of Alaska, bringing the total released on seamounts since 1999 to 2,800. Seamount tagging began in 1999 in an effort to determine whether fish which travel to the seamounts ever return to the continental slope. Seven fish released on seamounts in 1999 and two fish released in 2000 were recovered on the slope in 2000 and 2001, proving that emigration does occur. Seven tagged fish were recovered in 2000 and 21 in 2001, all from the same seamounts where they were released in 1999 or 2000. So far, no sablefish has been

recovered on a seamount other than the one where it was released. Seamount tagging will continue in 2002.

For more information, contact Nancy Maloney at (907) 789-6060.

Archival Sablefish Tags

During the 1998, 2000, and 2001 sablefish longline surveys, a combined total of about 463 sablefish were surgically implanted with an electronic archival tag. Two fish were tagged and released at each station from the eastern Aleutian Islands and eastern Bering Sea throughout the Gulf of Alaska to Dixon Entrance. The archival tag contains a computer chip that records depth and temperature for a period of 1-1/2 to 2 years. Data from these tags will provide information about sablefish behavior in the sea as well as the marine environmental conditions they experience. To date, 33 tags have been recovered. A $500 reward per tag is being offered to fishermen for the recovery of these tags. Plans are to release an additional number of sablefish with implants of archival tags during the 2002 longline survey. However, the reward for return of the archival tags released in 2002 will be lowered to $200.

Based on the recovered tags, three daily movement patterns have been observed: random movement (irregular depth movements not related to time of day), diel vertical movement (greater depths during day and movement to shallower water at night), and reverse diel vertical movement (shallower depths during day and movement to deeper water at night).

For more information, contact Michael Sigler at (907) 789-6037.

Juvenile Sablefish Studies

Juvenile sablefish studies have been conducted by ABL in Alaska since 1984 and were continued in 2002. A total of 447juvenile sablefish (age 1+) were tagged and released during a cruise of the NOAA vessel *John N. Cobb* at St. John Baptist Bay near Sitka, in June 2002. This relatively small bay is the only known location in Alaska where juvenile sablefish have been consistently found.

During June 1-6, 2002 a total of 10 electronic tags were surgically implanted into juvenile, age 1+, sablefish captured in St. John Baptist Bay. The tags were programed to acoustically transmit a record of temperature and depth experienced by the fish. Mobile acoustic receivers located onboard the NOAA ship *John N. Cobb* were used to monitor juvenile sablefish behavior and habitat utilization in rearing locations. Short term objectives are to use electronic acoustically transmitting sonic tags to provide information on juvenile sablefish behavior and habitat use in nearshore rearing areas and on the timing and duration of the emigration from nearshore rearing habitat. Fixed acoustic receivers located along corridors leading from the rearing locations to the open ocean will be used to monitor the timing of juvenile emigration from their near shore rearing habitat to the more open waters of the Gulf of Alaska.

Longer term objectives are to utilize electronic archival electronic tags in addition to electronic acoustically transmitting sonic tags in order to provide information on juvenile sablefish behavior and habitat during their transition from nearshore rearing areas to the age at which they are intercepted by the fishery. Archival tags will be used to monitor the temperature and depth experienced by juvenile sablefish from the time they leave the nearshore rearing areas at age 1+ or greater until the time they recruit to the fishery at age 2+ or greater. The electronic archival tags would be programmed to record temperature and depth, be surgically implanted in age 1+ juveniles, and be designed for recovery in the commercial fishery at age 2+ or greater.

For more information, contact Thomas Rutecki at (907) 789-6051.

Young-of-the-Year Sablefish Age and Growth in the Gulf of Alaska

Experiments were completed in 2001 which examined the periodicity of otolith increment formation in the sagittal otoliths of juvenile sablefish (age 0, size range 73 mm to 186 mm). Otolith increments are alternating light and dark bands visible under a transmitted light compound microscope at magnifications of 250x to 1000x. A daily periodicity of otolith increment formation in juvenile sablefish (age 0) has been postulated, but never validated. The periodicity of otolith increment formation was tested in this study by chemically marking the otoliths of captive juvenile sablefish with strontium chloride ($SrCl_2$). Approximately 30 post-larval neustonic sablefish were captured along the continental shelf and transported alive to ABL on June 1, 2000. The fish were maintained in sea water tanks for up to 104 days. The water temperature was elevated and held at a constant 13 degrees C, and the photo period was lengthened and held at a constant 16 hrs of light per day. The otoliths were chemically marked by immersing the live fish in seawater containing 1000 ppm $SrCl_2$. For chemical marking, the fish were split into three groups of roughly equal size. The first group was marked in June, the second group was marked in July, and the third group was marked in August. Each group was marked twice over a period of between 15 - 17 days, and each group was sacrificed between 14 -17 days after the second marking event. The otoliths of marked fish were processed into thin sections and the resulting strontium bands were detected with electron scanning microscopy by staff at the University of Alaska Fairbanks. For each otolith, the number of increments between strontium bands was counted and compared to the number of days between $SrCl_2$ immersions. The number of otolith increments detected between strontium bands ranged from 10 to 25, and in general did not agree with the number of days between marking events (15 - 17 days, average percent error in agreement 19.5%). These results suggest that either the otolith increments detected in this study did not form with a daily periodicity or that the methods used in this study to detect otolith increments were not accurate. In either case, the use of a less complicated structure, such as the lapilli otolith, or a more accurate otolith increment detection method, such as scanning electron microscopy, may be required to validate the periodicity of otolith increment formation for the size range of juvenile sablefish examined in this study.

To investigate the use of lapilli otoliths in age determinations of juvenile sablefish, aging of lapilli otoliths was also completed in 2001 for fish collected in the Gulf of Alaska from 1999-2001. Up to 30 lapilli were read for daily age by staff under contract at the Hatfield Marine Science Center, Oregon State University. These age determinations will be used to estimate birth date and calculate growth rates for comparisons with year class strength, estimated from age-structured modeling of adult sablefish.

For more information, contact Dean Courtney at (907) 789-6006.

b. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

The sablefish assessment shows that sablefish abundance increased during the mid-1960's due to strong year classes from the late 1950's and 1960's. Abundance subsequently dropped during the 1970's due to heavy fishing; catches peaked at 56,988 mt in 1972. The population recovered due to exceptional year classes from the late 1970's; spawning abundance peaked again in 1987. The population then decreased as these exceptional year classes began dying off.

The longline survey abundance index increased 16% in numbers and 13% in weight from 2000 to 2001. These increases follow decreases from 1999 to 2000 in the survey abundance index of 10% in numbers and 8% in weight and in the fishery abundance index of 5% in weight, so that relative abundance in 2001 is slightly higher than in 1999. Fishery abundance data for 2001 were not analyzed because the fishery was still open at the time the assessment was completed. Exploitable and spawning biomass are projected to increase 4% and 2%, respectively, from 2001 to 2002. Alaska sablefish abundance now appears to be low and slowly increasing. The slow increase confirms the conclusion from last year's assessment that the abundance trend will increase slowly due to the above-average 1995 and 1997 year classes; the size of the increase depends on the actual strength of the above-average 1997 year class and the 1998 year-class, which is also likely above average. Spawning biomass is projected to increase to 35% of unfished spawning biomass in 2002, having been as low as 33% during 1998 to 2000.

A simple Bayesian analysis was completed by examining the effect of uncertainty in natural mortality and survey catchability on parameter estimation. A decision analysis was completed using the posterior probability from the Bayesian analysis to determine what catch levels likely will decrease abundance. The decision analysis indicates that a yield of 17,300 mt will maintain spawning biomass. The maximum permissible yield from an adjusted $F_{40\%}$ strategy is much higher, 21,300 mt. The $F_{40\%}$ yield was not recommended because it had a high probability of decreasing abundance. An ABC value of 17,300 mt was recommended for the combined stock in 2002. This yield is likely to maintain spawning biomass and is slightly higher than the 2001 ABC of 16,900 mt.

For more information, contact Mike Sigler at (907) 789-6037 or Sandra Lowe at (206) 526-4230.

D. Other Related Studies

Effects of Fishing on Sea Floor Habitat:

Effects of Bottom Trawling on Soft-bottom Sea Whip Habitat in the Central Gulf of Alaska

In April 1987, the North Pacific Fishery Management Council closed two areas around Kodiak Island to bottom trawling and scallop dredging (Type 1 Areas). These areas were designated as important rearing-habitat and migratory corridors for juvenile and molting crabs. The closures are intended to assist rebuilding severely depressed Tanner and red king crab stocks. In addition to crab resources, the closed areas and areas immediately adjacent to them have rich stocks of groundfish including flathead sole, butter sole, Pacific halibut, arrowtooth flounder, Pacific cod, walleye pollock, and several species of rockfish.

These closures provide a rare opportunity to study the effects of an active bottom trawl fishery on soft-bottom, low-relief marine habitat because bottom trawling occurs immediately adjacent to the closed areas. In 1998 and 1999, ABL initiated studies to determine the effects of bottom trawling on these soft-bottom habitats. Direct comparisons were possible between areas that were consistently trawled each year and areas where bottom trawling had been prohibited for 11 to 12 years. The proximity of the closed and open sites allowed for comparison of fine-scale infauna and epifauna diversity and abundance, and microhabitat and community structure.

Analyses completed indicate that 1): trawling intensity, although high for the Gulf of Alaska, is relatively low compared to other areas worldwide, and 2) effects on the sedimentary and biogeochemical features of the seafloor and infauna community structure from present levels of bottom trawling were minor, and clear patterns were not detectible. Although epifaunal community structure analyses are incomplete, a clear relationship between total epifaunal biomass and sea whip abundance is apparent. This relationship indicates that sea whip habitat may have increased productivity. Recent studies in the Bering Sea have shown a similar functional relationship for sea whip habitat.

In June 2001, ABL scientists initiated a second study to investigate the immediate effects of intensive bottom trawling on soft-bottom habitat and in particular on an area colonized by sea whips. Sea whip biological characteristics and their resistance to two levels of trawling were studied. A before-after-control-impact (BACI) type study design was used. Sea whips are highly visible, and changes in their abundance can be readily quantified. Within the study site, at least two species of sea whips (*Halipterus* sp. and *Protoptilum* sp.) are present with densities up to 16 individuals per m^2. Sea whip beds provide vertical relief to this otherwise homogeneous, low relief habitat. This habitat may be particularly vulnerable since sea whips can be removed, dislodged, or broken by bottom fishing gear. Furthermore, because sea whips are believed to be long-lived, recolonization rates may be very slow.

The study consisted of three phases. In Phase 1, baseline data were collected. The *Delta* submersible was used to collect *in situ* videographic documentation of the seafloor along 20 predetermined transects within the study area. Additionally, a bottom sampler was deployed from the submersible tender vessel to collect sediment samples from the seafloor. During Phase 2, a commercial trawler outfitted with a Bering Sea combination 107/138 net, mud gear, and two "NETS" High Lift trawl doors made a single trawl pass in one corridor of the study area and repetitively trawled (six trawl passes) a second corridor. Catches were sampled for species composition, and stomachs were collected from 10 groundfish species caught during trawling activities to identify important prey items. Phase 3 repeated the videographic and sediment sampling following the trawling phase. A scientist inside the *Delta* observed the seafloor in synchrony with the external cameras and vocally identified

biota and evidence of trawling, including damaged or dislodged biota and marks on the seafloor from the various components of the bottom trawl (e.g., trawl door furrows, and ground gear striations).

The 2001 study will allow quantification of effects resulting from known levels of trawling, and the experimental trawling will allow testing of hypotheses related to the observed 1998-99 sediment and infauna changes. Additionally, the 2001 study will provide information for evaluating measures to minimize fishing effects such as area closures or gear modifications; and if on-bottom observations can be made in future years, an evaluation of sea whip recolonization and changes in productivity relative to sea whip abundance can be completed.

For more information, contact Robert Stone at (907) 789-6031.

Research on "Habitat Areas of Particular Concern"

A survey of a potential Habitat Area of Particular Concern (HAPC) was carried out by ABL in late May 2000. The manned submersible *Delta* was used to run transects at the site about 20 km W of Cape Ommaney, Baranof Is., southeastern Alaska during a series of 7 dives. The submersible was tracked at 30 sec intervals from the support vessel using DGPS and an ultra-short baseline acoustic tracking system. Continuous images of the sea floor were obtained using an externally-mounted video camera fitted with a laser scaling device. The audio tracks on the videotapes were used to note time when the transects began and ended, water depth, estimated current velocity, substrate, megahabitat and microhabitat characteristics, lateral water visibility, faunal assemblages, behavior and associations of individual species within those assemblages, presence of derelict fishing gear along transects, and any damage to epifaunal invertebrates.

The area of the potential HAPC site that was surveyed measures approximately 400 x 600 m with maximum vertical relief of 55 m, and water depths range between 201 and 256 m. The area studied is likely a ridge projecting southeastward from the 200 m isobath on the continental shelf, and may be part of a series of such features. The substrate is primarily bedrock and large boulders, most likely composed of mudstone, and provides abundant cover in the form of caves and interstices of various sizes. The epifaunal community is rich and diverse, much more so than the surrounding low-relief sand-gravel habitat. Largest epifauna were gorgonian red tree coral colonies and several species of sponge. These organisms were not randomly distributed at the study site. Numerous species of fish, particularly adult and sub-adult rockfish, were present in relatively large numbers and were often associated with gorgonian coral colonies and several species of sponge. Derelict longline gear was commonly observed, as were dead and damaged red tree coral colonies.

The submersible depth and location data were used to produce a precise bathymetric chart of the site by Nautical Solutions Inc., of Annapolis, MD. Data on physical and biological parameters recorded in real time on the submersible system's event log, as well as data recorded on the video and audio tapes, have been entered into computer files. These are being formatted for GIS, and a series of chart overlays depicting locations of particular habitat features and associated biota will be produced.

In June 2001 the submersible *Delta* was also used to make a series of dives in the northeastern

Gulf of Alaska to observe sites where significant quantities of red tree coral had been brought up during past NMFS trawl surveys. A total of 20 dives were made at 16 locations. The video and audio data are currently being analyzed, and the information will be presented as a series of chart overlays similar to those being produced for the May 2000 dives.

For more information, contact Linc Freese at (907) 789-6045.

Growth and Recruitment of an Alaskan Shallow-water Gorgonian

At least 20 species of gorgonian corals inhabit Alaskan waters. Specimens of all but one species have been incidentally entangled in fishing gear (e.g., hook and line, longlines, trawls, crab pots, and fish traps) and detached from the seafloor. Several species attain large size and provide habitat in the form of structure and refuge for species of demersal fish and invertebrates. The effects of coral habitat alteration on benthic communities are unknown, but may be substantial due to the reported longevity and slow growth rates of cold-water corals. The North Pacific Fishery Management Council is currently considering measures to establish several marine protected areas where gorgonian corals are abundant. A study to examine the growth and recruitment of *Calcigorgia spiculifera*, a shallow-water gorgonian, was established in 1999 to provide insights into gorgonian growth rates, validate radiometric aging techniques, and elucidate the effects of fishing activities on coral habitat.

Computer image analysis tools were used to measure the linear length of colony branches from digitized video images collected by scuba diving on tagged specimens. Length of a branch was measured along the medial axis from the point opposite its origin. This method provides a permanent record of colony morphometry. Highly accurate measurements are possible with proper colony orientation with respect to the calibration grid and parallel alignment of the camera lens with the grid.

Thirty five colonies were tagged at 2 sites in southeastern Alaska in July 1999. Thirty two (91%) and thirty (86%) of those colonies were found again when the sites were revisited in 2000 and 2001, respectively. The five missing colonies had presumably detached from the seafloor. Growth measurements were possible for 16 colonies in 2000 and 21 colonies in 2001. Growth rate was variable for branches from the same colony and also between colonies. Mean branch growth rate at both sites ranged from -1.82 to 14.83 mm yr^{-1} in 2000 and -0.80 to 9.7 mm yr^{-1} in 2001. Growth rates (2000 mean = 5.81 mm yr^{-1}, sd = 4.99, 2001 mean =2.95 mm yr^{-1}, sd = 2.66) measured during both years were generally much lower than those reported for other gorgonians worldwide, including Alaskan *Primnoa*, a deep-water species. Recruitment of new colonies had not occurred at either study site for a minimum of several years indicating that recruitment in this species, at least at our study sites, is a rare sporadic event.

The slow growth rates measured so far in this study, although preliminary, are noteworthy because shallow-water corals are widely believed to have faster growth rates and shorter life spans than deep-water corals. Additionally, recruitment appears to be a rare, sporadic event. Shallow-water gorgonian communities may therefore exhibit slow recovery rates from sea floor perturbations. Future

research priorities are to focus on growth of smaller colonies and to establish a third study site where colonies are more numerous and more variable in size (i.e., age).

For more information, contact Robert Stone at (907) 789-6031.

Study of Alaskan Sponges

A recent study of the effects of mobile fishing gear on the benthos of the continental shelf in the eastern Gulf of Alaska has shown that several species of large, erect sponge provide important components of structural habitat on the seafloor, and are particularly susceptible to removal or damage by commercial trawling activity. No sign of recovery from trawl damage was noted during a follow-up investigation conducted one year post-trawl. In contrast, experimental trawling carried out in warm, shallow water on the continental shelf of the southeastern U.S. has shown that sponge communities are quick to recover to pre-trawl abundances and that individual damaged sponges undergo rapid regeneration. Because the ability of benthic epifauna to recover from trawl damage may be a consideration in future Fishery Management Plans, ABL biologists initiated a study of several species of sponge in 2001. A small community of sponges was previously discovered at scuba diving depths in Seymour Canal, Admiralty Island, southeastern Alaska. Several of the species present were also found in deeper waters on the continental shelf in the Gulf of Alaska.

The purpose of this study is to determine some basic life history parameters of shallow, cold-water sponges. Growth and regeneration is of particular interest. Annual observations began at the Seymour Canal site in April 2001, and at an additional site located at south Benjamin Is., near Juneau, Alaska, in December 2001. We hope to collect further information regarding large-scale distribution, habitat associations, and recruitment. During 2001 we 1) roughly charted the distribution of the sponge communities; 2) tagged 76 individual sponges at both sites; 3) took manual measurements of individual sponges; 4) videotaped individual sponges so growth can be measured; and 5) removed pieces of a known size from individual sponges to examine regenerative ability and to determine species through spicule analysis. In 2002 we will revisit both sites to conduct follow-up studies.

For additional information contact Linc Freese at (907) 789-6045.

Living Substrates in Alaska: Distribution, Abundance and Species Associations

"Living substrates" have been identified as important marine habitat and are susceptible to impacts from fishing activities. In the Gulf of Alaska, Aleutian Islands, and Bering Sea, little is known about the distribution of deepwater living substrates such as sponges (Phylum Porifera), sea anemones (Order Actiniaria), sea whips and sea pens (Order Pennatulacea), sea squirts (Class Ascidiacea), and ectoprocta (Phylum Bryozoa). In order to facilitate management practices that minimize fishery impacts to these living substrates, distributional maps were created based on National Marine Fisheries Service

trawl survey data from 1975 through 2000. In general, the five groups of living substrates were observed along the continental shelf and upper slope in varying densities. Catch-per-unit-effort (CPUE) of sponges was greatest along the Aleutian chain, while CPUE of sea squirts and ectoprocta was greatest in the Bering Sea. Large CPUE's of sea anemones, sea pens, and sea whips were observed in both the Bering Sea and Gulf of Alaska. Species associations between living substrates and commercial fish and crab were also investigated. Flatfish were most commonly associated with sea squirts and ectoprocta; gadids with sea anemones, sea pens, and sea whips; rockfish and Atka mackerel with sponges; and crab with sea anemones and sea squirts.

For more information, contact Patrick Malecha at (907) 789-6053.

Alaskan Coral Identification

The "coral" fauna of Alaska is poorly known. Much of the taxonomic literature describing many of the Alaskan species is old and difficult to obtain. Although Alaskan cold-water corals are widely distributed and often abundant, materials for taxonomic studies have not been readily available. The recent interest in essential or critical fish habitat and the need to identify species contributing to "living substrates" has provided opportunity to improve our knowledge of critical species and to develop guides to their identification. In cooperation with Dr. Steven Cairns of the Smithsonian Institution and the Alaska Department of Fish and Game Bering Sea/Aleutian Island Crab Observer Program, we are building reference and teaching collections at ABL and Dutch Harbor. A "Preliminary Field Key to the Alaskan Hydrocorals" has been developed and is being distributed for informal testing. Keys and field guides to the Octocorals ("gorgonians") are planned but require additional collections and resolution of taxonomic problems.

For more information, contact Bruce Wing at (907) 789-6043.

Habitat Evaluation of Major Fishing Grounds

The Sustainable Fisheries Act of 1996 was passed to attain long term protection of essential fish habitat, and it specifically requires that NMFS minimize adverse impacts to essential fish habitat by fisheries that it manages. While considerable legal and administrative effort has been expended to meet the requirements of the Act, there has been little effort to observe the habitat where ongoing fisheries occur. NMFS has limited knowledge of bottom habitat where major fisheries occur. Any regulatory measures adopted to minimize impacts without the knowledge of whether or where vulnerable habitat is at risk may be ineffective or unnecessarily restrictive. This study, initiated by ABL in 2001, is an effort to attain such knowledge.

During summer 2001 high-resolution echosounder data (multibeam and backscatter) and video data were collected on the Portlock Bank area of the central Gulf of Alaska in the vicinity of extensive

bottom trawl and longline fisheries for groundfish. The echosounder data were collected by RV *Davidson,* and the video data were collected from the manned submersible *Delta.* The objective of the study was to characterize bottom habitat in or near heavily fished grounds to understand whether habitats in current fishing grounds are vulnerable to ongoing fishing activities. The area mapped by echosounder was about 1000 km^2 of the outer continental shelf and upper continental slope. Preliminary interpretations of multibeam and backscatter data indicate the presence of at least a dozen different benthic macro- or mesohabitats. The megahabitats of this area are distinctly the result of past glaciation with the glacial deposits presently being reworked and shaped into moderate (cm-m) relief features. Many submarine canyons notch the upper slope and provide steep relief with alternating mud-covered and consolidated sediment exposures. The video data showed little evidence of trawling on the flatter grounds of the continental shelf, where perhaps the relatively level bottom does not induce door gouging and there is a lack of boulders to be turned over or dragged. The most common sessile epifauna were crinoids, small non-burrowing sea anemones, glass sponges, stylasterid corals, and two species of brittlestars. Occasional large boulders located in depressions were the only anomaly in the otherwise flat seafloor. These depressions may have afforded benthic fauna some protection from fishing gear, as the glass sponges and stylasterid corals attached to these boulders were larger than were typically observed. In the fished areas of the upper slope, there was evidence of boulders turned over or dragged by trawling. The uneven bottom of the slope may have induced gouging by the trawl doors. The substrate was mostly small boulders, cobble, and gravel. Presently there does not appear to be much habitat within the entire study area that can be damaged by trawl impacts. No large corals and very few large sponges were seen. Whether this is the result of past trawl activity is unclear.

For more information, contact Jon Heifetz at (907) 789-6054, Dean Courtney at (907) 789-6006, or Jeff Fujioka at (907) 789-6026.

Studies on Sea Lion/Groundfish Interactions:

Seasonality of Prey Availability in Regions of Contrasting Steller Sea Lion Abundance Trends

The Auke Bay Laboratory began research in 2001 to test the hypothesis that sea lion prey diversity and seasonality are related to Steller sea lion population trends. The decline in the western population of Steller sea lions may be due to decreased prey availability; this decrease may be exacerbated by fishery removals of prey in sea lion habitat. Area-specific diet diversity and population change of Steller sea lions also appear to be related, with faster declines in areas of lower diet diversity (Merrick et al. 1997). Steller sea lions also may switch diet seasonally, as different prey become more available. The purpose of this set of studies is to test the hypothesis that sea lion prey diversity and seasonality are related to Steller sea lion population trends. The approach is to measure Steller sea lion prey, prey quality (free fatty acid analysis), and predator abundance and fishery removals near selected rookeries and haul-outs, emphasizing seasonal measurements conducted during critical life stages of Steller sea lions. Two regional trend areas, Southeast (SE) Alaska and the Kodiak area, are being

compared. Study haul-outs and rookeries were selected based on year-round accessibility; simultaneous sampling of sea lion abundance, distribution, and diet (scats) is occurring by other cooperating agencies. The University of Alaska currently is conducting a seasonal study on Kodiak Island, an area where Steller sea lion abundance is declining. The ABL is studying sites in SE Alaska, where Steller sea lion abundance has been stable. In SE Alaska, ABL is cooperating with the Alaska Department of Fish and Game, the University of Alaska, and the North Pacific Universities Marine Mammal Research Consortium. This study also is being coordinated with the existing University of Alaska study on Kodiak Island.

For ABL's SE Alaska study, two study sites were selected where Steller sea lions are known to haul-out in relatively large numbers: 1) Benjamin Island, north of Juneau, and 2) the Brothers Islands in Frederick Sound. Field work began in March 2001, and each site has been visited on at least a quarterly basis since then. Prey abundance at each site is determined by echo-integration and midwater trawling, and sea lion scat is collected from the haul-outs to infer diet. Fish are also collected for proximate and free fatty acid analysis. These studies will be continued in 2002 and 2003.

For more information, contact Michael Sigler at (907) 789-6037.

Seasonal Composition, Distribution, and Habitat of Species Available as Forage for Steller Sea Lions in Nearshore Waters in the Vicinity of Sea Lion Haul-Outs in Southeastern Alaska

The nearshore waters in the vicinity of two sea lion haul-outs, Benjamin Island and the Brothers Islands in southeastern Alaska were sampled in summer 2001 and winter 2002. A total of 22 sites were beach-seined in shallow (<10 m deep) habitats, 23 sites 10 to 80 m deep were jigged, and 16 sites 10 to 90 m deep were surveyed with a remotely operated vehicle (ROV). Thirty-nine fish species were captured of which 10 are know to be prey of sea lions. In summer, catch of fish per seine haul was 67 at Benjamin Island and 6,119 at the Brothers Islands; the highest total catch of any species was about 65,000 walleye pollock, *Theragra chalcogramma*, at the Brothers Islands and about 600 at Benjamin Island. For jigging in summer, catch of fish per rod hour was 5.6 at Benjamin Island and 5.7 at the Brothers Islands. The same sites will be sampled in summer 2002 and winter 2003.

For more information, contact Scott Johnson at (907) 789-6063 or John Thedinga at (907) 789-6025.

Shark Predation of Steller Sea Lions

In August 2001 a study was conducted by ABL scientists to test the hypothesis that sleeper sharks prey on Steller sea lions. Longlines were used to capture sleeper sharks around Steller sea lion rookeries in the central Gulf of Alaska during times of pup vulnerability to determine if live Steller sea

lions are prey for sleeper sharks. Twenty-one longline sets were completed near four Steller sea lion rookeries from 30 July 2001 through 10 August 2001 aboard the chartered fishing vessel *Norska*.

The diet of sleeper sharks was investigated by collecting stomach content data (including micro satellite DNA-based identification of questionable prey items) and by fatty acid analysis of tissue samples. Ninety-nine sleeper sharks were collected. Predominant prey items included walleye pollock, octopus, unidentified teleost fish, salmon, and cetacean tissue. Also, the vertical distribution of sharks was measured by tagging methods for comparison to the vertical distribution of Steller sea lions while at sea. Nine sleeper sharks were tagged and released with electronic pop-up archival transmitting tags which are programmed to release (pop-up) from the animal on a pre-determined date and time, and transmit the archived data and current location to a satellite.

A second and final cruise is scheduled for 10-21 May 2002. Shark stomach samples will be collected for diet analysis and an additional twenty-four archival tags are to be released to strengthen the biological information on depth, activity, and movements.

For information contact Leland Hulbert (907) 789-6056 or Michael Sigler at (907) 789-6037.

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